Feb. 20, 1951 W. M. ROBERDS 2,542,841

HIGH-FREQUENCY COUPLING APPARATUS

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Fig. 1.

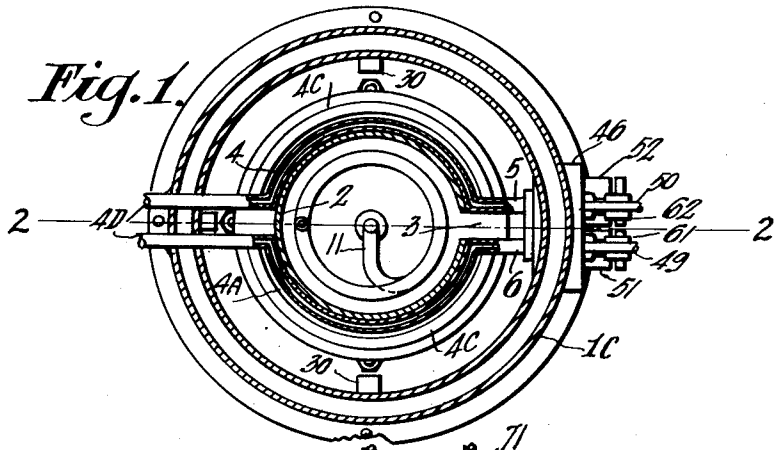


Fig. 2.

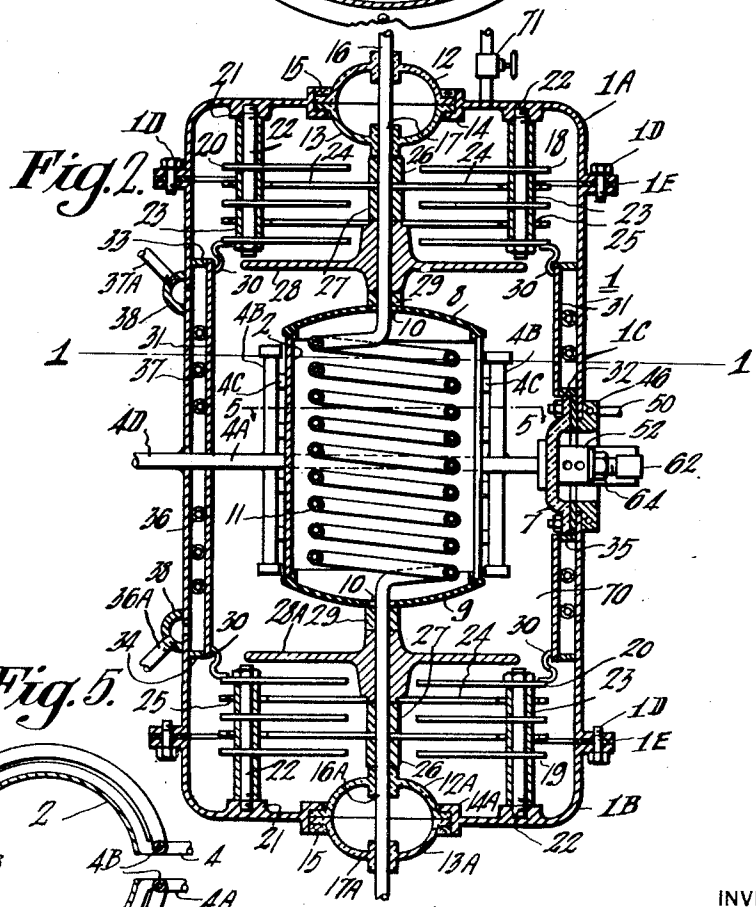
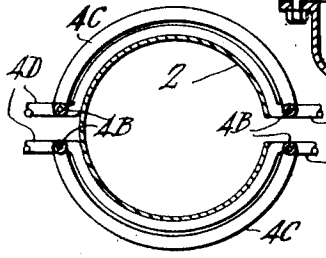


Fig. 5.



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Fig. 4.

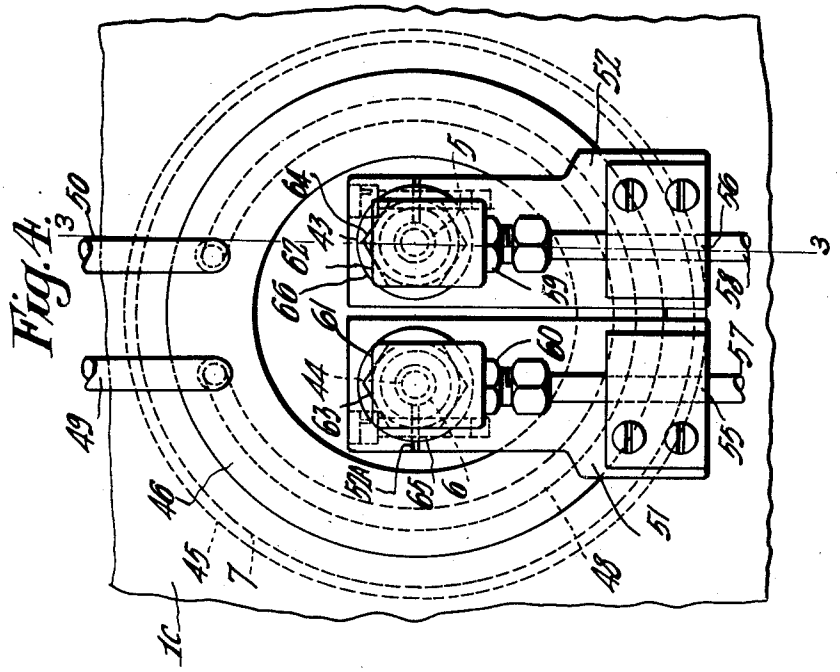
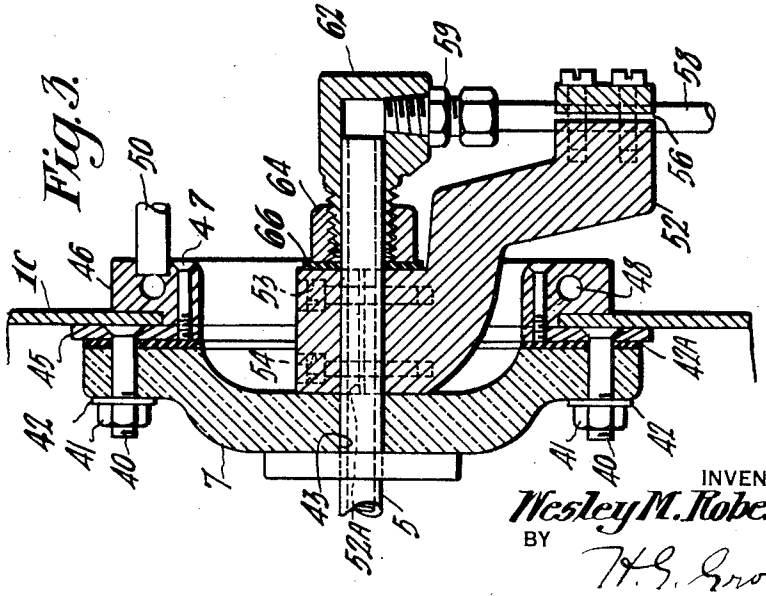


Fig. 3.



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HIGH-FREQUENCY COUPLING APPARATUS

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Application February 18, 1946, Serial No. 648,476

11 Claims. (Cl. 250—16)

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This invention relates to improved high frequency apparatus which is particularly adapted for feeding high radio frequency currents from any suitable source to a load or work circuit which is to be heated by the radio frequency currents.

An object of this invention is to provide a novel tank circuit for a high power oscillator to couple electrical energy from powerful oscillator tubes to an industrial work circuit in which the work is heated by radio frequency currents.

This application discloses further improved cooling and shielding features of the high frequency apparatus of my copending application Serial No. 487,133, filed May 15, 1943, which has now matured into Patent No. 2,404,404, dated July 23, 1946.

A feature of this invention is the novel combination of a tank circuit and a high frequency current transformer which are built together as a unit and located within a metallic container. The container is maintained under high gas pressure for the desired electrical insulation. The tank circuit unit of this invention includes all the principal parts of a high frequency wave generator with the exception of the tubes and control circuit.

The device of this invention is for use in radio frequency circuits having a frequency range on the order of from 100 kilocycles per second to approximately one megacycle per second.

This invention will be described in greater detail with reference to the accompanying drawing, in which:

Fig. 1 is a cross-sectional view of the high frequency apparatus of this invention, the section being taken on line 1—1 of Fig. 2;

Fig. 2 is a longitudinal section of Fig. 1, the section being taken on line 2—2;

Fig. 3 is an enlarged detail section of the secondary terminal fluid cooling system, the section being taken on line 3—3 of Fig. 4;

Fig. 4 is an elevation of Fig. 3; and

Fig. 5 is a cross-sectional view taken on line 5—5 of Fig. 2, a portion of the structure being omitted.

Referring now in detail to Figs. 1 and 2 of the drawing, the metallic casing 1 is constructed in three portions 1A, 1B and 1C which are joined together by any suitable means. The inner wall of the metal container 1 is preferably plated with copper or silver in order to keep down any stray energy losses which might be encountered in the high frequency circuit in which this device is to be employed. The casing 1 is preferably constructed of heavy steel to withstand the heavy

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gas pressure. The three portions are joined after the structural elements are assembled therein. The central casing portion 1C is provided with an outwardly projecting flange located at each end thereof. The upper and lower portions 1A and 1B respectively of the casing have provided at one end thereof a similar flange to that of the central portion 1C. The three portions are shown as being joined by a plurality of bolts 1D. A gasket 1E is interposed between the flanges to provide a gas tight seal when the sections of the casings are joined together. Located within the central portion 1C of casing 1, there is a copper cylindrical secondary inductive member 2. The secondary inductive member 2 is split at 3 to prevent a short circuited turn effect and has located at the central portion thereof, two integral fluid ducts 4 and 4A which are preferably welded or brazed to the sides of the secondary 2.

As shown by Fig. 5 of the drawing, the fluid ducts 4 and 4A are provided with suitable headers 4B which project above and below each fluid duct. The headers 4B all have suitable apertures to receive additional cooling fluid tubes 4C which tubes are in the form of semi-circular tubes which are joined at the apertures to the headers to provide additional fluid cooling to the secondary 2. The fluid ducts 4 and 4A pass through opposite sides of the casing, one side indicated as 4D. The tubes at 4D are welded directly to the casing 1 and form a mid-point or ground connection for the secondary inductive member 2. The opposite or high potential ends of the fluid ducts pass through a flanged bowl shaped insulator 7 to form two terminal fluid cooling inlet and outlet tubes 5 and 6 respectively. The terminals 5 and 6 are insulated from casting 1 by being arranged to pass through the flanged bowl-shaped insulator 7. The constructional details of the terminals and insulator will be described later in connection with Figs. 3 and 4. At each end of the cylindrical secondary, there are located convex insulators 8 and 9. Each insulator has located therein a central aperture 10 through which passes a tubular primary winding or inductive member 11. The primary inductive winding together with the secondary 2 forms a radio frequency transformer. The primary winding consists of any desired number of turns of copper tubing forming a spaced helical coil. The tube provides fluid cooling, which fluid is derived from any suitable source, such as, for example, an external water supply (not shown). The ends of the tube forming the primary winding 11 are supported and insulated at each end

of the metallic container 1 by the insulating bells 12, 12A, 13 and 13A which are secured to a seat portion 14 and 14A formed integral with the walls of casing 1. The insulating bells are preferably secured to the container 1 by any suitable means, such as cement 15. The ends of the copper tube which pass through the bells are sealed in a gas tight manner at 16, 16A, 17 and 17A.

Two condenser elements 18 and 19 are located within the casing ends, the condenser element 18 being secured at the upper end of the casing and the condenser element 19 being located at the lower end of the casing. Each condenser element includes a plurality of circular plates 20 which are secured to the inner wall of casing 1 by means of an internal boss 21 which is tapped to receive threaded spacing rods 22. Each condenser plate is supported on the rods and properly spaced by means of spacers 23. The plates 20 are maintained at ground potential and, therefore, can be directly connected electrically to the casing 1. Interposed between each of the plates 20 there are additional circular plates 24 which are maintained at a high potential with respect to the casing and are insulated from the plates 20 by means of a suitable aperture 25, the aperture being sufficiently large with respect to the spacers 23 to provide the proper voltage gap. Each of the plates 24 is spaced apart from plates 20 by means of metal spacers 26 and 27 which surround the copper tube of the primary winding 11. To protect the condenser plates from the radio frequency field created by the transformer elements, metallic end shields 28 and 28A are provided and are secured to each end of the primary winding 11. The shields are of copper plate with a heavy central hub and are soft soldered to the primary winding 11. They also act to center the winding with respect to the condenser plates. Each end shield is electrically connected to the high potential plates 24 and spaced from the insulators 8 and 9 by means of spacing members 29. The two inner end plates 26 are arranged to carry a plurality of bronze contact springs 30 which are positioned to make electrical contact with a metallic ground shield or jacket 31 and the condenser plates 20. The ground shield 31 is preferably in the form of a copper cylinder, and protects the steel casing, and acts as a ground conductor from the plate capacitor 19 and the grid capacitor 18. The central portion of shield 31 is cut away to form a circular aperture 32 necessary to provide the proper clearance and electrical insulation between insulator 7 and the secondary terminal construction. The ends of the shield 31 are closed by metallic rings 33 and 34. A circular bent ring 35 closes the aperture 32. Interposed between the inner casing wall and the outer portion of the shield there are provided two helical fluid cooling ducts 36 and 37 which are connected together in fluid communication and provide a fluid cooling duct through which cooling fluid (preferably water) may be circulated. The cooling fluid enters the tubes at a suitable fitting inlet 36A and goes out through an outlet 37A, both of which are preferably threaded into a boss portion 38 welded to the outside of casing 1. The cooling fluid tube 36 is soldered to the jacket or ground shield 31 to maintain good thermal contact therewith.

Referring now in detail to Figs. 3 and 4 of the drawing, the secondary terminal insulator 7 is in the form of a flanged shaped porcelain bowl. Preferably this insulator is composed of ceramic material, and is secured to the inner wall of casing 1 by means of a plurality of threaded studs 40, the studs being supported by a metallic ring 45 which is fastened to the inner wall of the steel casing 1. Each one of the studs is provided with clamping nut 41 and suitable gasket material 42 and 42A. Apertures 43 and 44 are located in a central position on porcelain bowl 7. The metallic ring 45 has also secured thereto an outer copper ring 46 which is made in two parts, inner and outer. Ring 46 is brazed in place or it may be secured by any suitable means such as a plurality of flat head screws 47. Because of heating localized around the terminals 5 and 6, the copper ring 46 has a fluid duct 48 which is provided to keep the ring and the secondary terminals 5 and 6 water cooled by means of water circulating through the duct, the entry of the fluid being made at the upper inlet tube 49 and leaving through the outlet tube 50. The secondary 2 is cooled by means of fluid passing through tubes 4 and 4A, which fluid path also includes the headers 4B and the semi-circular tubes 4C. The water enters tube 4 at 40 and leaves through tube 4A at the end 4D, at which point the secondary is maintained at ground potential by the connection of tubes 4 and 4A to casing 1. To provide the high potential electrical connection to the secondary winding 2, heavy copper lugs 51 and 52 are secured to the terminal tubes 5 and 6. In Figs. 3 and 4 there is shown how each of the lugs is split at 52A to permit the water cooled tubes 5 and 6 to be clamped thereto by means of a plurality of machine screws 53 and 54. The lower portions of lugs 51 and 52 are cut away at 55 and 56 to receive inlet tube 57 and outlet tube 58 which connect to an applicator. The ends of the inlet and outlet tubes 58 and 57 respectively are soldered to standard quarter inch brass pipe connector members 59 and 60, the latter members being threaded and soldered into brass elbows 61 and 62. Brass nuts 63 and 64 are provided on elbows 61 and 62 to make a fluid tight connection between terminal lugs 51 and 52 and terminal tube members 5 and 6, the nuts being clamped against washers 65 and 66 which are constructed of suitable gasket material. After the parts of the device of this invention are assembled and the three portions of the casing are joined, then an insulating gas 70 which is preferably nitrogen or Freon, or a mixture of the two, is pumped under pressure of approximately 150 pounds per square inch in through the gas valve 71 to provide the proper condenser dielectric and insulating medium.

What is claimed is:

1. High frequency apparatus comprising a metallic casing, an electrical shield and a fluid cooling means extending along a substantial portion of the inside wall of said casing and in intimate contact therewith, a transformer hollow inductive member insulatingly supported within said casing by the ends thereof, means for passing a cooling fluid through said member, an insulator secured to the central portion of the side wall of said casing, a second transformer inductive member spaced from said electrical shield and inductively coupled to said first mentioned inductive member and supported at one side by said insulator and at the other side by said casing, and a fluid duct electrically connected to said second member and arranged to pass through said insulator.

2. High frequency apparatus comprising a

metallic casing having a central aperture therein, an electrical shield and a fluid cooling means extending along a substantial portion of the inside wall of said casing and in intimate contact therewith, an insulator positioned in said central aperture and secured to said casing, a transformer inductive member insulatingly supported within said casing by the ends thereof, means for passing cooling fluid through said member and through said fluid cooling means, a second transformer inductive member spaced from said electrical shield and inductively coupled to said first mentioned inductive member, and a fluid duct electrically connected to said second member and arranged to pass through said insulator.

3. High frequency apparatus comprising a metallic casing, an electrical shield and a fluid cooling jacket extending along a substantial portion of the inside wall of said casing and in intimate contact therewith, a transformer hollow inductive member and condenser elements, both of which are insulatingly supported within said casing by the ends thereof, means for passing a cooling fluid through said member and through said fluid cooling jacket, an insulator secured to said casing and positioned over an aperture in the central portion of the side wall of said casing, a second transformer inductive member inductively coupled to said first mentioned inductive member, hollow terminals for said second member passing through said insulator, and a fluid cooling duct located adjacent said insulator and surrounding said hollow terminals.

4. High frequency apparatus comprising a metallic casing, a transformer hollow inductive member insulatingly supported within said casing by the ends thereof, means for passing a cooling fluid through said member, an electrostatic shield surrounding said member and concentric with said casing and having a fluid cooling means associated therewith, an insulator positioned within an aperture in said shield and secured to the casing over an aperture in the central portion of the side wall of said casing, a second transformer inductive member inductively coupled to said first mentioned member and supported in part by said insulator, and a fluid duct having a plurality of semi-circular tubes electrically connected to said second member, a portion of said fluid duct being electrically connected to said casing.

5. High frequency apparatus of the type having condenser elements located within and supported from each end of a metallic casing, comprising fluid cooling means extending along a portion of the inside wall of said casing, an insulator secured to the side wall of said casing and positioned over an aperture in the side wall of the casing, a transformer hollow inductive member insulatingly supported within and by the ends of said casing, means for passing a cooling fluid through said member, a second transformer inductive member inductively coupled to said first mentioned member, and a fluid duct secured to and electrically connected to said second member and arranged to pass through said insulator.

6. High frequency apparatus of the type having two sets of condenser elements located within a metallic casing, said sets of condenser elements being respectively supported from different ends of the metallic casing member, comprising an electrical shield and fluid cooling means interposed between the two sets of condenser elements and extending along the inside wall of said casing, a transformer hollow inductive member insulatingly supported within and by the ends of said casing, means for passing a cooling fluid through said inductive member, an insulator secured to the side wall of said casing and positioned over an aperture in the central portion thereof, a second transformer inductive member inductively coupled to said first mentioned inductive member, a pair of hollow terminals for electrically connecting the ends of said second member, said terminals passing through said insulator, and a fluid cooling duct secured to the casing adjacent said insulator and surrounding said hollow terminals.

7. High frequency apparatus of the type having two sets of condenser elements located within a metallic casing, said sets of condenser elements being respectively supported from different ends of the metallic casing member, comprising fluid cooling means interposed between the two sets of condenser elements and extending along the inside wall of said casing, a transformer hollow inductive member insulatingly supported within and by the ends of said casing, means for passing a cooling fluid through said inductive member, an insulator secured to the central wall portion of said casing, a second transformer inductive member inductively coupled to said first mentioned inductive member, a pair of hollow terminals, for electrically connecting the ends of said second member, said terminals passing through said insulator, a fluid cooling duct secured to the casing wall and surrounding said hollow terminals, and fluid connection means secured to and communicating with said fluid cooling duct.

8. High frequency apparatus of the type having two sets of condenser elements located within a metallic casing, said sets of condenser elements being respectively supported from different ends of the metallic casing, comprising an electrical shield and fluid cooling means interposed between the two sets of condenser elements and extending along the inside wall of said casing, a transformer hollow inductive member insulatingly supported within said casing by the ends thereof, an electrical shield for each set of condenser elements located at each end of said first mentioned electrical shield, means for passing a cooling fluid through said inductive member, an insulator secured to the side wall of said casing and positioned over an aperture in the central portion thereof, a second transformer inductive member inductively coupled to said first mentioned member, a pair of hollow terminals for electrically connecting the ends of said second member, said terminals passing through said insulator, and a fluid cooling duct secured to the casing adjacent said insulator and surrounding said hollow terminals.

9. A high frequency apparatus of the type having two groups of spaced condenser plates, each group being located within and respectively supported from different ends of a metallic casing, comprising an electrical shield and fluid cooling means interposed between the two groups of condenser plates and extending along the inside wall of said casing, a transformer hollow inductive member insulatingly supported within said casing by the ends thereof, an electrical shield for each group of condenser plates located at each end of said first mentioned electrical shield, means for electrically connecting some of the spaced condenser plates to said first mentioned electrical shield, means for passing a cooling fluid through said inductive member, an insulator secured to the side wall of said casing and positioned over

an aperture in the central portion thereof, a second transformer inductive member inductively coupled to the first mentioned member, and a pair of hollow terminals for electrically connecting the ends of said second member, said terminals passing through said insulator.

10. A tank circuit for high frequency heating apparatus comprising a hollow metallic casing containing therein in the order named, a first condenser, a coil winding and a second condenser mounted and supported between opposed ends of said casing, a hollow coil winding contained in said casing and surrounding said first coil winding and inductively coupled thereto, hollow terminals external of said casing for connecting to said hollow coil winding for supplying fluid thereto which is adapted to flow through said hollow coil winding, and a fluid cooling duct also external to said casing and surrounding said hollow terminals.

11. A tank circuit for high frequency heating apparatus comprising a hollow metallic gas filled casing containing therein in the order named, a first condenser, a coil winding and a second condenser mounted and supported between opposed ends of said casing, a hollow coil winding contained in said casing and surrounding said first

coil winding and inductively coupled thereto, hollow terminals external of said casing for connecting to said hollow coil winding for supplying fluid thereto which is adapted to flow through said hollow coil winding, and a fluid cooling duct also external to said casing and surrounding said hollow terminals.

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